



City of Coeur d'Alene

WASTEWATER DEPARTMENT

Phase 5 Program Schedule

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Introduction

The City of Coeur d'Alene will undertake an ambitious capital improvement program to meet new effluent discharge requirements for the Spokane River. The planned Phase 5 improvements to the City's wastewater treatment plant will be the most expensive project ever undertaken by the City and will take a number of years to complete. Figure 1 presents a simplified, overall program schedule for compliance with the requirements of the draft NPDES permit. The improvements to the Coeur d'Alene Advanced Water Reclamation Facility are targeted to be on-line by early in 2016. The draft February 2007 NPDES permit compliance schedule milestones are identified in Figure 1 and highlight the requirements for the City to report on progress made in accomplishing interim steps towards full compliance. It is anticipated that the new draft NPDES permit expected to be issued by Region 10 EPA in early 2010 will include similar requirements. Upon completion and commissioning of the facility, it is anticipated that a period of 2 years of operation will be required to optimize performance and produce the lowest levels of effluent phosphorus possible.

Wastewater Facilities Plan Amendment

A final 2009 Wastewater Facility Plan Amendment has been prepared and approved by the Idaho Department of Environmental Quality. The 2009 Wastewater Facility Plan Amendment updated the 2000 Wastewater Facility Plan and the 2002 Predesign Report of the Coeur d'Alene Wastewater Treatment Plant Phase 4B/4C Expansion. The 2009 Wastewater Facility Plan Amendment focuses on treatment alternatives evaluation with an emphasis on the technology selection to achieve a monthly average effluent phosphorus concentration of less than 50 µg/L. Much of the past facility planning analysis remains unchanged by new discharge conditions on the Spokane River and is retained as part of the City's wastewater management program. The 2000 Wastewater Facility Plan and 2009 Wastewater Facility Plan Amendment provide a flexible, long-term management strategy for Coeur d'Alene, while identifying a phased implementation program to meet capacity and treatment requirements into the future.

The previous 2000 Wastewater Facilities Plan also identified the need for reliable compliance with ammonia-nitrogen limits and the need for addressing treatment improvements necessary to accommodate projected wastewater flow. The principal treatment areas addressed in the subsequent project were identified for the secondary treatment process, anaerobic digestion and sludge storage. It was identified that the improvements should be in place when the nominal plant flow reaches 4.2 mgd. The improvements identified as Phase 4C in the 2000 Wastewater Facility Plan are labeled in the 2009 Wastewater Facility Plan Amendment as Phase 5B and Phase 5C. The previous plan improvements are very similar to the new plan improvements. The 2009 Wastewater Facility Plan Amendment redefines and relabels the Phase 4C planned improvements as Phase 5B and 5C.

Effluent Discharge Permitting

The City received a draft NPDES permit on February 15, 2007 and final permits were originally expected to be issued early in the 2008 calendar year. However, delays in the completion of the

Spokane River dissolved oxygen total maximum daily load (TMDL) being prepared by the Washington Department of Ecology have resulted delays with the associated NPDES permits. It is anticipated that the new draft NPDES permit expected to be issued by Region 10 EPA in early 2010.

The draft 2007 permit prepared by EPA proposed several major changes from the historical discharge permit, including significantly lower interim and final CBOD and phosphorus limits, along with effluent ammonia nitrogen limitations. Another significant change in the 2009 version of the Spokane River TMDL is the expansion of the seasonal control requirements for phosphorus, BOD and ammonia to begin in March. The earlier seasonal effluent limits will be more difficult to meet because of lower wastewater temperatures earlier in the spring that reduce reaction rates in the nitrification process. By comparison, the existing effluent ammonia limits begin 4 months later in July and end in September. New ammonia limits are expected to begin in March and extend through October as shown in the 2007 draft permit, with provision of interim limits that require only monitoring and reporting during the new months.

The draft 2007 permit prepared by EPA also includes a 9 year compliance schedule for CBOD, ammonia, and phosphorus, with interim limits for CBOD and phosphorus. The draft 2007 permit prepared by EPA included a compliance schedule with a complex structure with multiple milestones that requires that the City report on progress made in accomplishing interim steps towards full compliance. Milestones include the following:

- ◆ Submit an engineering report to EPA and IDEQ one year after the effective date of the permit outlining the estimated costs and schedules for completing capacity expansion and implementation of technologies to meet the final effluent limitations.
- ◆ Provide written notice to EPA and IDEQ that pilot testing of the technology that will be employed to achieve final limits has been completed and submit a summary report on results and plans for implementation within 4 years of the effective date of the permit.
- ◆ Provide EPA and IDEQ written notice that design has been completed and bids awarded to begin construction of facilities to meet final effluent limitations by the expiration date of the final permit.
- ◆ Provide EPA and IDEQ written notice that construction has been completed on facilities to meet final effluent limitations within 7 years of the effective date of the permit.
- ◆ Complete start-up, optimization, and achieve compliance with final effluent limitations by within 9 years of the effective date of the permit.
- ◆ Provide EPA and IDEQ written reports which outline the progress made toward achieving compliance with the phosphorus, ammonia and CBOD effluent limitations by 2, 3, 6 and 8 years after the effective date of the permit. Reports must include the following, at a minimum:

- ◆ Assessment of the previous year of effluent data and comparison to the effluent limitations.
- ◆ A report on progress made toward meeting the effluent limitations.
- ◆ A report on progress made toward completing remaining interim requirements of the compliance schedule.
- ◆ Further actions and milestones targeted for the next year.

Phosphorus Management Plan

The draft NPDES permit includes a provision calling for the development of a Phosphorus Management Plan. The EPA included this provision in the draft NPDES permit fact sheet with the statement: “Because the Spokane River and Lake Spokane’s assimilative capacity for nutrient discharges is very small, and because it will be several years before the permittee will be able to fund, design, build, and optimize capital improvements to the treatment plant, EPA believes it is reasonably necessary in this case for the permittee to use best management practices to control or abate the discharge of phosphorus from the wastewater treatment plant.” As a result of this provision, the City will be required to develop and implement a Phosphorus Management Plan within 1 year of the effective date of the final permit, and implement the plan within 18 months of the effective date of the final permit.

Several of the conditions which the EPA requires in the Phosphorus Management Plan are addressed in this Wastewater Facility Plan Amendment. However, some conditions have yet to be addressed. A Phosphorus Management Plan would compile the responses to all of the required conditions in a single document.

Conditions of Phosphorus Management Plan

- ◆ The City must compile influent and effluent phosphorus data for the wastewater treatment plant.
- ◆ The City must evaluate the wastewater treatment plant’s phosphorus reduction potential.
 - ◆ The City must compare its phosphorus concentrations against typical values for wastewater treatment plants utilizing similar treatment technology.
 - ◆ If the phosphorus concentrations are higher than typical levels, the permittee must investigate the cause of the high phosphorus concentrations and take steps to reduce phosphorus concentrations.
- ◆ The City must set phosphorus reduction goals for the wastewater treatment plant.
 - ◆ The phosphorus reduction goals must be consistent with interim or final phosphorus effluent limits, as appropriate, or with typical values for the type of treatment process employed by the wastewater treatment plant,

whichever results in lower effluent phosphorus concentrations or greater reductions in total phosphorus.

- ◆ The City must set an influent phosphorus reduction goal.
- ◆ The City must evaluate the phosphorus reduction potential of non-domestic users of the POTW.
- ◆ The Plan must list the non-domestic users of the treatment works which fit the following categories:
 - (i) Agricultural co-ops.
 - (ii) Car/truck washing facilities.
 - (iii) Dairies.
 - (iv) Food processing plants.
 - (v) Meat packing and locker plants.
 - (vi) Metal finishing facilities.
 - (vii) Municipal water treatment plants that add phosphorus to drinking water.
 - (viii) Nursing homes.
 - (ix) Restaurants.
 - (x) Schools.
 - (xi) Any other non-domestic users of the POTW which contribute at least 5% of the total influent phosphorus loading to the POTW.
- ◆ In the Plan, the permittee must evaluate which of these non-domestic users have the greatest opportunity for reducing phosphorus.
- ◆ For those non-domestic users which the permittee determines to have potential to reduce phosphorus loading to the POTW, the permittee must work with the business to develop a phosphorus reduction goal.
- ◆ The City must provide written notice to EPA and IDEQ that it has implemented its phosphorus management plan within 18 months of the effective date of the final permit. The implementation must be consistent with an implementation plan which must include the following elements:
 - ◆ A listing of the phosphorus reduction strategies that the permittee will use to meet its phosphorus reduction goals. The City must select and describe phosphorus reduction strategies for the following four areas, if applicable. The implementation plan must note which of the following four areas are

included in the plan, and which were omitted. For those areas which are omitted, the implementation plan must explain the omission.

(i) Non-domestic users.

(ii) The wastewater treatment plant.

(iii) Residential or domestic users.

◆ (iv) Drinking water treatment plant.

◆ For each group of phosphorus contributors listed in the implementation plan, the City must consider the following phosphorus reduction strategies and list which strategy or strategies it will employ for phosphorus reduction.

(i) Source reduction or prevention (e.g., process changes and water recovery for industrial users and restrictions on the sale or use of phosphate detergents for domestic users).

(ii) Best practices.

(iii) Education (e.g., information about environmentally preferable purchasing of low or non-phosphorus products).

(iv) Staff training (at the WWTP and for non-domestic users).

(v) Pretreatment (for non-domestic users).

(vi) Phosphorus removal at the WWTP (chemical, physical, and biological methods).

(vii) Ongoing monitoring.

(viii) Wastewater re-use.

◆ The permittee must revise the Phosphorus Management Plan whenever it is found to be ineffective in achieving the phosphorus reduction goals.

◆ The City has also requested that EPA and DEQ provide phosphorous reduction credit to the treatment plant and reassess the final phosphorous effluent limits based on any non point source phosphorous reductions achieved through plan implementation. The Spokane River Managed Implementation Plan established to achieve the load and waste allocations in the draft Spokane River Dissolved Oxygen TMDL allow for credits to the Washington dischargers for non point source control programs.

Planned Phase 5 Treatment Improvements

The recommended plan consists of continued treatment using the existing treatment facilities at the City's Advanced Water Reclamation Facility and construction of a parallel treatment train followed by tertiary treatment to achieve the new effluent water quality limits.

Liquid Treatment Processes

Pretreatment. The existing influent screening and grit removal improvements from Phase 4B would continue to be used for pretreatment.

Primary Treatment. Conventional clarification using circular basins with chemical assistance has been assumed.

Biological Treatment and Advanced Filtration. An activated sludge system followed by tertiary series media filtration or membranes, or alternately membrane bioreactors (MBRs) is recommended. With additional disinfection, the system will be capable of meeting Class A reclaimed water standards with the entire plant flow. A plug flow activated sludge system has been assumed. During the summer, the activated sludge system will be operated with anaerobic, anoxic, and aerobic zones to provide biological phosphorus removal and nitrification and denitrification (NDN) such that river discharge requirements for phosphorus and ammonia nitrogen are met. Additionally, total nitrogen requirements shall be met for Class A reclaimed water for effluent reuse in urban irrigation, industrial reuse, and wetlands restoration. During the March through October phosphorus removal period anticipated to be required in the NPDES permit, alum may be fed to the MBR system for phosphorus control. Low concentrations of ammonia-nitrogen are not needed in the winter to meet water quality requirements. There may be an economical mode of operation that does not provide full nitrification during the winter permit season. The Advanced Water Reclamation Facility may also be operated with nitrification/denitrification year-round for alkalinity and pH control. All equipment associated with mixed-liquor pumping, permeate pumping, waste-activated sludge (WAS) pumping, secondary scum pumping, process air supply, and membrane scour air supply will be provided within the overall biological treatment and advanced filtration facility.

Disinfection and Dechlorination. Disinfection will be provided using an ultraviolet light (UV) system.

Reclaimed Water Pumping. The City is considering implementation of a reclaimed water program, providing Class A reclaimed water for reuse in urban irrigation, industrial reuse, wetlands restoration, and other non-potable water uses. Initially, this program will use reclaimed water for irrigation on the water reclamation facility site. Consequently, the site layout and hydraulic profile must accommodate a reclaimed water pumping station. The primary disinfectant for the reclaimed water will be ultraviolet light to provide 5-log virus inactivation.

Chemical Feed Systems. A chemical feed and storage building will be constructed to house the following feed systems: alum, ferric, sodium hypochlorite, citric acid, polymer, methanol,

supplemental alkalinity addition (if required), and other chemical systems necessary to meet effluent phosphorus discharge limits and maintain the membrane system and other plant systems.

Solids Handling Processes

Grit and Screenings Handling. Grit is washed, classified and hauled to a landfill. Screenings are washed, compacted and hauled to landfill.

Primary Sludge Thickening. A gravity sludge thickening process is used for primary sludge. If necessary in the future, this process could be retrofit to a thickening/fermentation process to produce supplemental volatile fatty acids that would be sent to the activated sludge process to improve the performance of the biological phosphorus removal step.

Secondary and Chemical Sludge Thickening. The biological and chemical sludge streams are combined for thickening using a rotary screen thickening (RST) process.

Sludge Stabilization. Single-stage, mesophilic digestion has been assumed for sludge stabilization.

Digested Sludge Storage. Liquid sludge storage would be provided for periods when icy roads prevent hauling of biosolids from the plant site.

Sludge Dewatering. Dewatering is provided via centrifuges.

Dewatered Sludge Storage. On-site dewatered sludge storage is assumed to be unnecessary since biosolids can be hauled to a storage hopper at the City's compost facility.

Centrate Equalization. Centrate from the dewatering is stored and metered back to the activated sludge process to equalize ammonia loadings to the liquid treatment train.

Preliminary Program Costs

An estimate of program costs has been prepared for the Phase 5 program improvements recommended in the *2009 Wastewater Facilities Plan Amendment* and updated in the *2009 Phase 5 Preliminary Design Report*. The Opinion of Probable Cost (OPCC) for the Coeur d'Alene Advanced Water Reclamation Facility expansion compares three treatment process alternatives. Table 1 summarizes the actual costs for the parts of the Phase 5 program that have been completed or bid and underway to date along with the estimated costs for the remaining parts of the Phase 5 program discussed in the *2009 Phase 5 Preliminary Design Report*. The alternatives presented in Table 1 match the alternatives presented in the 2009 Wastewater Facility Plan Amendment.

- ◆ Alternative 1 – Existing Trickling Filter/Solids Contact (TF/SC) and New Conventional Activated Sludge (CAS) with Biological and Chemical Phosphorus Removal and Tertiary Membrane Filtration

- ◆ Alternative 2 – Existing Trickling Filter/Solids Contact (TF/SC) and New Conventional Activated Sludge (CAS) with Biological and Chemical Phosphorus Removal and Tertiary Dual Sand Filtration (2-Stage Moving Bed Media Filtration)
- ◆ Alternative 3 – Existing Trickling Filter/Solids Contact (TF/SC) and New Membrane Bioractor (MBR) with Biological and Chemical Phosphorus Removal and TF/SC Tertiary Membrane Filtration

Table 1. Summary of Estimated Capital Costs of Coeur d'Alene Advanced Water Reclamation Facility

Phase 5 (6 mgd)	Alternative 1	Alternative 2	Alternative 3
COMPLETED OR CURRENTLY ACTIVE PHASE 5 PROJECTS			
2008 Integrated Fixed Film Activated Sludge (IFAS) Pilot			
Actual IFAS Media Prepurchase (December 2007)	\$224,433	\$224,433	\$224,433
Actual Construction Cost (Project Complete June 2008)	\$42,852	\$42,852	\$42,852
Actual Engineering Cost	\$80,456	\$80,456	\$80,456
SUBTOTAL 2008 IFAS PILOT	\$347,741	\$347,741	\$347,741
Low Phosphorus Demonstration Pilot Facility			
Actual Tertiary Membrane and Membrane Bioreactor Bid Price	\$1,141,460	\$1,141,460	\$1,141,460
Actual 2-Stage Moving Bed Media Filter Bid Price	\$306,000	\$306,000	\$306,000
Actual Construction Price (after Change Order No. 1, Feb 2010)	\$1,195,933	\$1,195,933	\$1,195,933
Actual Engineering Cost	\$841,932	\$841,932	\$841,932
SUBTOTAL LOW P DEMONSTRATION PILOT	\$3,485,325	\$3,485,325	\$3,485,325
Phase 5A (Near Term Ammonia Improvements) and Phase 5B (Solids Processing Improvements)			
Actual Rotary Screen Thickener Prepurchase Cost (March 2009)	\$58,741	\$58,741	\$58,741
Actual IFAS Media Prepurchase (December 2008)	\$246,901	\$246,901	\$246,901
Actual Phase 5A Construction Cost (Project Complete July 2009)	\$190,076	\$190,076	\$190,076
Estimated Phase 5B Prepurchase Owner-Furnished Equipment	\$125,000	\$125,000	\$125,000
Actual Phase 5B Construction Bid Amount (Project Bid December 2010)	\$10,632,100	\$10,632,100	\$10,632,100
Actual Engineering Cost	\$3,023,524	\$3,023,524	\$3,023,524
Construction Engineering, Observation, and Systems Integration	\$1,999,478	\$1,999,478	\$1,999,478
SUBTOTAL PHASE 5A AND PHASE 5B	\$16,275,820	\$16,275,820	\$16,275,820
ACTUAL COSTS FOR COMPLETED PHASE 5 PROJECTS			
	\$20,108,886	\$20,108,886	\$20,108,886
FUTURE PHASE 5C PROJECT			
Phase 5C – Liquid Stream Improvements			
Primary Clarifier	\$630,332	\$630,332	\$630,332
Primary Clarifier Cover	\$640,157	\$640,157	\$640,157

Phase 5 (6 mgd)	Alternative 1	Alternative 2	Alternative 3
Aeration	\$2,965,521	\$3,087,550	-
Blower Building	\$1,403,980	\$1,403,980	-
Chemical Storage and Feed	\$121,320	\$121,320	\$121,320
RAS/WAS Pumping	\$979,353	\$979,353	-
Secondary Clarifier	\$1,672,411	\$1,834,274	-
Membrane Bioreactor (inc, RAS/WAS, Aeration Basins, Blowers)	-	-	\$12,952,164
Tertiary Filtration (membrane)	\$7,573,063	-	\$5,420,033
Tertiary Filtration (mbfm)	-	\$7,817,579	-
Yard Piping and Ductbanks	\$2,740,100	\$3,224,962	\$2,050,471
Yard Piping and Ductbanks (Riverside Interceptor)	\$176,059	\$176,059	-
Electrical	\$3,410,906	\$3,562,897	\$3,160,825
Instrumentation and Controls	\$951,334	\$999,389	\$875,294
Basin Covers	\$138,590	\$138,590	\$97,872
Subtotal Estimated Construction Amount PHASE 5C (1)	\$23,403,126	\$24,616,442	\$25,948,468
Mobilization, Bonds and Insurance (10%)	\$2,340,313	\$2,461,644	\$2,594,847
Contractor's Overhead and Profit (10%)	\$2,340,313	\$2,461,644	\$2,594,847
Subtotal	\$28,083,751	\$29,539,730	\$31,138,162
Miscellaneous Items Not Itemized (15%)	\$4,212,563	\$4,430,960	\$4,670,724
Escalation to the mid-point of construction	\$4,589,306	\$4,827,235	\$5,088,443
Subtotal	\$36,885,620	\$38,797,925	\$40,897,329
Engineering legal and fiscal (25%)	\$9,221,405	\$9,699,481	\$10,224,332
PHASE 5C SUBTOTAL	\$46,107,025	\$48,497,406	\$51,121,661
Range of Accuracy based on AACE 17R-97 for Class 5 Estimate -10%	\$41,496,323	\$43,647,666	\$46,009,495
Range of Accuracy based on AACE 17R-97 for Class 5 Estimate +20%	\$55,328,430	\$58,196,888	\$61,345,993
TOTAL PHASE 5			
Total Phase 5 Estimated Cost ³ (Low)	\$61,605,209	\$63,756,552	\$66,118,381
Total Phase 5 Estimated Cost ³ (High)	\$75,437,316	\$78,305,774	\$81,454,879

See next page for footnotes.

¹Costs are based on April 2009 dollars (20-City ENR-CCI of 8,528.39).

²Estimated capital costs have been escalated to the projected mid-point of construction in January 2013 based upon a straight line extrapolation of historical Northwest construction cost indices.

³Total probable construction cost for Phase 5C only since the escalation to mid-point of construction is highly variable and virtually unpredictable beyond 10 years.

Low Phosphorus Demonstration Pilot Testing

During the summer of 2006, four different technology vendors took part in a short duration, small scale pilot testing program at the Coeur d'Alene Wastewater Treatment Plant. The primary objective of this testing was to demonstrate the ability of the tested technology to achieve 10 µg/L to 50 µg/L effluent total phosphorus on a monthly average basis. The May 2007 pilot study report "Tertiary Phosphorus Removal Technology Pilot Study" presents a complete description of the treatment technologies and the results of the testing.

At least three of the four technologies tested reliably demonstrated effluent TP of less than 50 µg/L. However, all pilots were operated by the vendor's application engineers who were intimately familiar with their technology. None of the four technologies achieved less than 10 µg TP/L. The high level of soluble non-reactive phosphorus, which is likely a function of local water chemistry, made effluent concentration below 10 µg/L impossible via chemical addition and particle retention.

While the pilot testing program provided valuable treatment process information for the *2009 Wastewater Facility Plan Amendment*, many questions remain regarding the full scale performance under the variability of influent flows and loads, full scale reliability from equipment failures, plant maintenance requirements, and the lack of time for process optimization and staff training given the compliance schedule.

Demonstration Testing Program Primary Objectives

The overall objectives of Demonstration Testing are to provide a platform for operator training, answer questions regarding reliability, assess process impacts from variability in flows and loads, and provide a degree process optimization not available in the small scale pilot in 2006. Design criteria for the full-scale facility will be refined and a key objective is to reduce the cost of the capital improvement program, and to improve reliability, if possible. The City's 2006 pilot testing investigation and the current Low Phosphorus Demonstration Testing program have been conceived and designed to demonstrate what degree of phosphorus removal is feasible.

Performance Reliability

Seasonal variations in phosphorus removal performance are possible and may be driven by the impact of the local water chemistry on the soluble non-reactive phosphorus fraction. The four week demonstration pilot during the summer of 2006 did not capture the impact of seasonal changes in water chemistry. During the 2006 pilot, the feed flow to the individual pilot was constant and the impact of diurnal variation of flows and loads and from storm events was not captured. The impact of seasonal water chemistry changes and diurnal variation are believed to affect the performance of any treatment process for low phosphorus.

The Demonstration Testing will help the City to assess the reliability of each candidate process under variable (diurnal, seasonal, and storm influenced) influent conditions throughout the permit season and identify factors related to design, operation strategy, and process control that could negatively impact performance reliability.

Balance of Biological and Chemical Phosphorus Removal

Few membrane bioreactor (MBR) facilities with biological nutrient removal (BNR) are known to be in operation in North America as of October 2007. The benefits of biological phosphorus removal are compelling thus many wastewater treatment facilities with effluent phosphorus limits operate under biological phosphorus removal with chemical backup.

Some uncertainty remains as to whether biological phosphorus removal with chemical backup can work effectively to achieve very low phosphorus limits. Performance at facilities that operate Bio-P can produce effluent Ortho-phosphorus concentrations in the 10 to 20 µg/L range from time to time. However, being biological in nature, these systems never perform at these low levels continuously. Thus, chemical backup is needed and would be used to reduce the possibility for excursions over the permit requirements.

Unfortunately, chemical backup could potentially suppress biological phosphorus removal by binding available reactive phosphorus and disrupting the uptake and release cycle necessary for phosphate accumulating organisms (PAOs) to survive. In addition, the required stoichiometric overdosing may void any potential savings that can be accomplished by biological phosphorus removal. Some industry experts have expressed caution regarding the success of Bio-P in this application. The opinions in the industry currently provide support both for and against this concept, and clear evidence has been presented to support either side. Therefore, this issue will require special focus during the demonstration pilot.

Process Automation and Control

Automation and process control integration must be reliable to meet the anticipated effluent quality requirements. Reliable automation and process control will:

- ◆ Minimize operational costs (i.e., chemical feed control, aeration control, etc)
- ◆ Support staffing needs (i.e., sample collection and analysis vs. online instrumentation)
- ◆ Enhance troubleshooting capabilities (i.e., remote monitoring)

Equipment for online monitoring of process and water quality parameters has evolved tremendously over the past decade. Today, a wide selection of equipment for nearly every desirable parameter is available. However, significant differences exist between available products with respect to everything from cost, sample analysis cycle time, to calibration and maintenance requirements. Therefore, the evaluation of online process monitoring equipment will be a key issue for the demonstration pilot. Parameters may include ammonia, nitrate, PO₄-P, DO, pH, MLSS, and/or turbidity.

Plant Staff Training

The Coeur d'Alene Wastewater Treatment Plant is preparing for a transition from conventional wastewater treatment plant to one of the most advanced treatment facilities in North America. This transition will undoubtedly present many challenges for the plant staff, including operators, maintenance personal, and laboratory staff. The new facility will not only feature new process design and operation strategies, but an entire array of new equipment with new maintenance

requirements, O&M manuals, new vendors, new troubleshooting procedures, and new calibration requirements.

Demonstration Testing Program Secondary Objectives

In addition to the primary objectives, a number of subjects warrant further investigation.

Continue Investigating Treatment Alternatives for <10 µg/L Total Phosphorus

Additional demonstration testing will continue to explore the potential for achieving lower effluent phosphorus limits. During the 2006 demonstration pilot, additional tests were conducted to determine the potential for lower effluent phosphorus.

Test Online and Bench-Top Analytical Equipment

During the pilot, and indefinitely in the future, the plant laboratory will need to conduct low level phosphorus analysis to satisfy regulatory reporting requirements and to provide operators with feedback necessary to adjust the process operations accordingly. Even if phosphorus is measured continuously online, some laboratory analyses will remain necessary to calibrate the field/online analyzers. Today, several options are available for both online continuous phosphorus analyzers and automated bench top analyzers. Online analyzers would be used to provide instant feedback to operators and can be used to control chemical dosage. The automated bench top analyzer would be used to minimize the workload for the lab staff and to improve the consistency of the analysis itself.

Implementation of the Demonstration Testing Program

At the center of this two year pilot program is a 150,000 gpd to 300,000 gpd treatment plant (three 50,000 gpd to 100,000 gpd treatment trains) that features the candidate treatment processes remaining from the wastewater facility planning and small scale pilot testing. Equipment selection for the pilot facility will focus on maximizing the pieces of equipment that can be re-used in the permanent, full scale facility. For example, this would include instrumentation, online analytical equipment, or chemical feed pumps.

A tertiary membrane filtration system, MBR system with process tanks, and a skid mounted two-pass continuous upflow media filtration system (2-stage moving bed media filtration or MBF2) has been purchased and is being installed in a building to house the pilot equipment at the Coeur d'Alene wastewater treatment plant. The treatment trains are supplemented with necessary auxiliary facilities such as chemical feed systems, additional tanks, instrumentation, disinfection, etc. The demonstration pilot of MBR requires process aeration tanks for the bioreactor portion of the facility. This increases cost over simply operating a membrane operating system. Both MBR and tertiary membrane filtration system give the City operators a chance to see membrane filtration in the field with its associated controls, cleaning processes, and hardware.

Two transfer pump stations are being installed to deliver raw (or screened) influent and secondary clarifier effluent to the pilot plant. A third pump station is being provided to send pilot plant effluent to the neighboring Harbor Center irrigation system to use reclaimed water for irrigation.

The core system of the pilot plant will be fully automated and include remote monitoring and control capability. Additional instrumentation will be tied into the pilot plant's SCADA system, such that all key operational parameters can be monitored and adjusted remotely. The SCADA system will be set up with the ability to log most process variables for troubleshooting.

After being constructed and commissioned in March of 2010, the demonstration testing facility will operate for two years, including the winter season. Operation of the demonstration testing processes will allow monitoring of performance over seasonal change periods that may impact phosphorus removal. This may allow design criteria for the full-scale facility to be refined and reduce the potential for seasonal variations to result in conditions that compromise full-scale plant performance.

Assistance in operation of the facility is currently planned to supplement City staff with potential assistance from students/interns during a 3 to 6 month startup period. During the second half of the first year, operations tasks would transition to the Coeur d'Alene Wastewater Treatment Plant staff and interns for the operators to begin to orient themselves with the new treatment technologies. The initial operations by City staff will be limited to specific tasks and gradually expand as staff availability and training progress permits.

During first half of the second year, the transition of operation to the plant staff will be complete and during the second half of the second year the pilot plant will be operated entirely by plant staff (staff availability permitting) and interns. With the remote monitoring capability, engineering staff and vendors will be available to assist plant operators in optimizing the process and during emergencies.

Phase 5 Improvements Predesign, Detailed Design and Construction

The recommended plan requires large scale modifications at the treatment plant and a substantial capital expenditure of approximately \$59M to \$79M (including Low P Demonstration Pilot, Near Term Ammonia Reduction Improvements, Solids Processing Improvements, and Liquid Stream Improvements). Traditional design, bid and build (DBB) implementation of the recommended improvements is planned and is consistent with the City's historical approach to capital improvements.

Predesign

The preliminary design focused on refinement of the facilities planning concepts into specifics which are used as the basis for the detailed design. Plant layouts and hydraulic profile are

finalized, as is any necessary land surveying and geotechnical investigations. Other testing and equipment evaluations were also conducted prior to or during the predesign development phase.

Historically, the predesign phase for Coeur d'Alene plant improvement projects has taken between one and two years to complete. In the case of the Phase 5 program, a two year period was included in the program schedule shown in Figure 1 to allow for input from the Demonstration Testing program from two summer seasons of operation. The volume of engineering work required for plant improvements to both liquid stream and solids stream processes, as well as predesign of the advanced filtration systems for low phosphorus effluent, will require more than one year to complete. Demonstration testing over at least one seasonal change period will provide key input on design criteria for the full-scale facility to establish the importance of water chemistry changes on phosphorus removal performance, especially for the liquid stream improvements. Therefore, a two year predesign period for the Phase 5 program is appropriate.

Detailed Design

The detailed design phase is focused on the production of plans and specification to serve as contract documents for bidding and selection of a general construction contractor to build the facilities improvements. Historically, the detailed design phase for Coeur d'Alene plant improvement projects has taken between one and two years to complete. In the case of the Phase 5 program, a two year period was included in the program schedule shown in Figure 1 based on a design period of approximately 8 months for design of the Phase 5B Solids Processing Improvements, another 20 months for the design of the Phase 5C Liquid Stream Improvements, and an allowance of 4 months for the Idaho Department of Environmental Quality (IDEQ) review of bidding documents, construction contractor bidding, and contract award.

The volume of engineering work required for detailed design of the plant improvements to both liquid stream and solids stream processes, as well as the design of the advanced filtration systems for low phosphorus effluent, will require at least 20 months to complete. A further complication on the Coeur d'Alene plant in terms of engineering complexity is the constrained plant site. The treatment plant site is small and congested relative to the capacity of the facility. This means that treatment process tankage all must be carefully arranged to allow room for construction, as well as operations and maintenance. Interconnected process piping, plant utilities, electrical power, controls, etc. must be routed between each unit process area and central facilities. Plant site congestion adds to the length of engineering time required to complete the design of such a complex and interconnected facility. Demonstration testing over two seasonal change periods will provide key input on design criteria for the full-scale facility to establish the importance of water chemistry changes on phosphorus removal performance. Therefore, a two year period for the Demonstration Testing is appropriate.

Construction Contractor Bidding and Award

The overall design period must also allow for review by the IDEQ, contract bidding, bid evaluation and construction contract award. Typically, this process consumes 3 to 4 months.

The minimum bid advertisement period is 4 weeks, however for a contract of this size it is not unusual to have construction contractor requests for extension and the need to issue addendum that lengthen the process.

General Contractor Prequalification Process

The City has determined from historical public works contracting experience that a general contractor prequalification process is an essential step in the procurement process to assure construction quality and to minimize risk of contract award to an unqualified bidder. The general contractor prequalification process that the City has utilized in the Phase 4B and Phase 5B contracts has been successful and demonstrated the value of this process. The general contractor prequalification process extends the schedule time required for contractor bidding beyond the minimums for conventional design/bid/build procurements. Potential construction contractor prequalification processes, bid review, City Staff and Council briefings on award, and formalization of the award process requires approximately 6 months, as shown in the Figure 1 program schedule.

Construction Phase

Historically, the construction phase for Coeur d'Alene plant improvement projects has taken between one and four years to complete. Table 2 summarizes some of the major capital improvements made to the treatment plant, including the original contract costs, construction duration, and construction expenditure per month. The range of average monthly construction expenditures was from less than one hundred thousand dollars per month to nearly half a million dollars per month. The largest and most recently completed construction contract, Phase 4B, had only two monthly construction payments larger than \$1M.

Table 2. Historical Coeur d'Alene Capital Project Expenditures Compared to Planned Phase 4C Improvements

Contract	Description	Actual Construction Cost, \$	Start Date	End Date	Duration, Months	Escalated Cost, 2007 Dollars	Expenditure Per Month, 2006 Dollars/Month
Phase 3A	Influent Pumping Retrofit, Preliminary Treatment	\$1,635,101	Sep-87	Dec-88	16	\$2,885,000	\$180,000
Phase 3B	Primary Treatment Upgrades	2614288	Nov-88	Mar-91	17	\$4,371,000	\$257,000
Phase 3C	Secondary TF/SC Upgrade	7,350,834	Oct-91	May-95	44	\$11,066,000	\$252,000
Phase 4A	Odor Control Disinfection System and Plant Utilities Improvements	760,604 557,442	Aug-98 May-01	Apr-99 Oct-02	9 18	\$1,004,000 \$682,000	\$112,000 \$38,000
Phase 4B	Peak Flow Improvements, Headworks, Influent Pumping Stations	12,345,988	May-05	Jun-07	26	\$12,697,000	\$488,000

In the case of the Phase 5C program, a three year period was included in the program schedule shown in Figure 1. This may be constrained by the volume of construction dollars that must be expended on a relatively constrained plant site with both liquid and solids stream improvements planned, and the need to operate the existing facility throughout construction. For the volume of construction estimated at approximately \$41M to \$61M, between \$1.1M and \$1.7M per month of construction would be required. This would be a record pace for construction at the Coeur

d'Alene plant and no previous capital projects would have expended this level of construction dollars for such an extended period.

Community Economic and Social Impacts

The overall Phase 5 program improvements to the wastewater facilities, including approximately \$41M to \$61M in Phase 5C construction, make this the largest capital improvement project ever undertaken in the City of Coeur d'Alene. By comparison, only one recent project in the City even approaches the size of the planned wastewater facility improvements. For comparison, the following capital projects are the largest projects recently undertaken in the City of Coeur d'Alene:

- Coeur d'Alene High Remodel/Expansion (2002). Approximately about \$14M financed with proceeds from 1998 voter approved School Plant Facilities levy.
- City Library (approximately 2006). Approximately \$6M financed by 67% voter approval of General Obligation bond.
- Lakes Middle School Remodel (2009). Approximately \$4M financed with proceeds from a 2002 voter approved School Plant Facilities Levy.
- Kroc Center (2009). Approximately \$38M financed by a grant through Salvation Army. Includes a \$36M endowment for operations and maintenance. Local residents raised approximately \$5M to obtain the grant.

The time required to gain community support and prepare the financing plan for such an expensive program is expected to be extensive and challenging. EPA provides guidance on affordability in a Workbook titled Interim Economic Guidance for Water Quality Standards (1995) which provides for tests of substantial and widespread economic impact. EPA generally defines these impacts in terms of a "municipal preliminary screener" at 1 to 2 percent of median household income. Kootenai County median household income in 2004 was \$41,639 based on US Census Bureau data. For Kootenai County, 1 to 2 percent of median household income would range from \$34.70 to \$69.40 per month. An initial analysis was conducted to determine the "order of magnitude" wastewater user rate impact that would result from implementation of the Phase 5 improvements. This analysis found that single-family monthly rates would increase from the current level of \$24.43 to a range of approximately \$35 to \$40, or more. Projected wastewater rates for Coeur d'Alene fall into this range of economic impact and are projected to exceed 1 percent of median household income. Detailed rate analysis will be required for a more complete understanding of the wastewater fees and affordability thresholds.

Testing, Start-up and Commissioning

Testing, start-up and commissioning of new liquid stream improvements is included in the estimated construction phase duration of 36 months. The construction contractor is required to complete and test all new treatment processes and operate them for a period of time with clean water tests before commissioning on wastewater, and finally turning completed facilities over to the City for operation. Once commissioned and operational on wastewater, the City Operations Staff can take-over the new facilities and begin to operate them.

Since effluent phosphorus limits are targeted at such low concentrations (down to 50 µg/l) it is expected that several summer seasons of operation targeting low concentrations will be required to master the operations. This challenge requires a combination of treatment process biology,

chemical feed, mechanical, electrical, and instrumentation systems to function together for successful operation. For this reason, an optimization period of two years has been included in the draft NPDES permit to provide the opportunity to operate with interim limits. This will allow freedom to explore operating strategies, chemical feed, instrumentation and controls to find the best combinations for the most effective overall operation. Provision of this optimization period will lay the foundation for improvement full-scale performance of the facility for the long term.

Treatment Process Optimization Experience

Treatment process optimization is often challenging for wastewater facilities, especially for complex systems that include a combination of treatment process biology, chemical feed systems, mechanical systems, electrical, and instrumentation and control systems. Two examples are discussed in the following sections that illustrate the time frames involved in pursuit of improved treatment process performance and optimization. In both cases, multiple year periods have been required for optimization.

Coeur d'Alene Phase 4B Dewatering System

A centrifuge dewatering system was installed in the Coeur d'Alene plant in 2005 and was placed into initial operation in February of 2006. The dewatering system includes a new centrifuge, an existing belt filter press, a digested sludge feed pumping system, a polymer feed system, and a vendor provided controls package to operate the centrifuge. Pilot testing of the centrifuge was conducted in 2002 and a special procurement procedure was undertaken to prepurchase the machine in 2003. Notice to Proceed to purchase the centrifuge was issued by the City in the Spring of 2004 and installation of the machine was delayed for a year from 2004 to 2005 due to other issues associated with the Phase 4B project and acquisition of land required for construction.

The initial polymer selection tests for dewatering were conducted December 2005, with initial start-up of centrifuge in February 2006. Revisions were required to the polymer system and the start-up activities begun again in April 2006 with different polymer. A new polymer delivery system was installed in May 2006. A Notice of Substantial Completion was issued for the dewatering system in July 2006.

Performance of the centrifuge and associated polymer system has been challenging and optimization of the system is on-going in the Spring of 2010. Initial operations in July 2006 encountered foaming problems related to polymer type and dosage. Optimization with additional SCADA controls was conducted from November 2006 through July 2007. Centrifuge control malfunctions began July 2007 and are continuing through February 2008. Troubleshooting activities were undertaken by Operations Specialists working with the City's Operations Staff and the Centrifuge Vendor in January 2008. Current plans for performance improvements include replacement of some control modules under warranty with the Centrifuge Vendor. Consideration is now being given to planning for revisions to the centrifuge drive unit and a renewed polymer selection process to improve solids capture. Most recently, a shallower pond

depth was attempted in consultation with Operations Specialists and the manufacturer's representatives with very promising results, but these changes have not been tested during the phosphorus removal season when the equipment could be processing chemical (alum) sludge. This troubleshooting process has taken more than two years since the original installation of the centrifuge and has extended more than two years beyond the original Notice of Substantial Completion in July 2006

Clean Water Services (CWS) Durham Plan

Clean Water Services (CWS) of Washington County, Oregon operates two of the most advanced wastewater treatment facilities in the country at Durham and Rock Creek. These plants are frequently used as reference points for low effluent phosphorus performance. The operations history at these plants is excellent and Operations Staff are quite sophisticated in running these advanced treatment plants.

The Durham plant includes biological and chemical phosphorus removal systems and ammonia nitrogen control for discharge to the Tualatin River. The liquid stream treatment process includes activated sludge in a biological nutrient removal configuration followed alum feed and effluent filtration. The effluent discharge permit is a complex watershed permit that includes multiple CWS facilities. Effluent phosphorus from the Durham plant must meet a median effluent phosphorus discharge limit of 100 µg/l. The Durham plant has operated successfully in meeting a median effluent limit of 70 µg/l phosphorus up until a recent permit relaxation to approximately 100 µg/l.

The Durham plant has been operated for low effluent ammonia and phosphorus for more than ten years. Optimization of the treatment process has been a multi-year effort. Process Control and Operations Staff indicate that process improvements and optimization is often requires more than one nutrient removal season to accomplish, since any modification to mechanical systems needs to be planned to be executed in the off-season. New experience with the modified process then awaits the next nutrient removal season.

Mike Mengelkoch of Clean Water Services had the following comments on optimization of a low phosphorus treatment system based on their full-scale experience at the Durham and Rock Creek plants:

"In my experience you'll need very good control in several areas to be successful. Namely, 1) fairly stable BPR; 2) reliable chemical dosing; 3) excellent turbidity and suspended solids control; and 4) adequate control of recycle phosphorus loads. There are a number of variables in each of these areas that must be monitored and controlled. It will take a lot of attention to detail, plus some time and experience to fine-tune each area. For example, they'll need to establish an anaerobic zone and grow some Bio-P bugs before there can be any Bio-P. Then the bugs need to be conditioned with a high initial DO, to work properly. And you'll need the proper amount of VFA's (volatile fatty acids) to complete the recipe. All this takes time and attention.

We had to rely on chemical removal methods (which interfere with Bio-P) to achieve our monthly median goal, during the first half of any given month. Then we had a small window of opportunity in the second half of the month, to experiment with Bio-P. Or we would experiment biologically in one train and rely on chemicals in the others, and blend the results. Or a combination of the two.

We have learned a lot through experience and working with others and know what works well for us and what doesn't. Some lessons can be applied elsewhere, but not all. Each plant and situation are unique."

Personal communication; e-mail from Mike Mengelkoch, February 4, 2008.

Financing Plan

The City had updated its Wastewater Rate Study in 2002 and identified funding mechanisms and anticipated rate impacts for the wastewater management program through the Phase 5 (formerly Phase 4C) program as defined in the 2000 Wastewater Facility Plan. Given the costs to construct and operate the treatment processes to achieve extremely low effluent phosphorus, the City plans to re-visit the rate study and financing plan. The new rate study to re-examine funding mechanisms and anticipated rate impacts for the new Phase 5 program is targeted for mid-2010 through the end of calendar year 2011. Based on the experience with 2002 Wastewater Rate Study, a period of one and one half to two years is needed to complete a rate study update, publish a draft, respond to comments, publish the final rate study, obtain City Council approval, and adopt new user charge schedules.

In addition to the rate study, the City will need time to seek and obtain judicial confirmation and financing. Judicial confirmation is required for public entities in the State of Idaho to enter into debt for improvements that are reasonable and necessary, otherwise a bond election is required. The Phase 5C project represents potentially \$60 million in financing during or shortly following an economic recession. Neither a bond election process nor judicial confirmation process is guaranteed to be successful.

Facilities Maintenance Improvements

The wastewater facility has a number of planned and in some cases, deferred maintenance programs which must be integrated with the overall Phase 5 capital improvement program. This includes an extensive plant painting program for both process equipment and facility structures. These efforts must be conducted with process units out of service, so they are best scheduled during non-peak periods in plant flows and loadings.

Current maintenance program activities have included replacement of the cover for Digester No. 2, painting of Digester No. 4, and painting of the Secondary Clarifier collector mechanisms. Digester No. 2 work was initiated in the Fall of 2007 and was completed in the Spring of 2008.

Digester No. 4 painting and the Secondary Clarifier painting projects are being completed in the in 2010.

Management of Reclaimed Water

The City has initiated a detailed Wastewater Effluent Reuse Feasibility Study that identifies reuse customers, sites, water demands, and distribution system infrastructure required for potential implementation. The Coeur d'Alene Advanced Water Reclamation Facility will produce an effluent which meets State of Idaho Class A reclaimed water quality standards. The City plans to consider the cost-effectiveness of reuse opportunities in conjunction with the potential for phosphorus loading reduction when selecting reuse projects for implementation.

The development steps necessary to implement a reclaimed water use program include demonstration project and a phased program of distribution system improvements to carry reclaimed water to end users. An initial demonstration project is planned to achieve regulatory permit support for reuse and show the positive aspects of effluent reclamation and reuse in an urban irrigation application. This reuse pilot project may be combined with the low effluent phosphorus demonstration testing program. The reuse pilot study can be operated during the summer seasons of 2010 through 2012. Future completion of the full-scale treatment plant improvements for effluent filtration will provide up to 6 mgd capacity of reclaimed water to supply the entire reuse program.

Combined Treatment Process Demonstration Testing and Reuse Demonstration Program

Effluent from the treatment systems constructed for a low phosphorus demonstration pilot could be used for a reclaimed water use demonstration project. A demonstration that is modest in size and cost could be an element of a successful public awareness project to support development of a water reuse program. If the City were able to show actual Class A reclaimed water being used on a small demonstration scale, the public may become more familiar with its application, safety, and benefits.

A water reuse demonstration project using Class A reclaimed water may be conducted relatively easily at the existing wastewater treatment facility. Class A filtration will be available for the low phosphorus demonstration. To qualify for Class A reclaimed water, supplemental disinfection is necessary. Supplemental disinfection could be in the form of chlorine addition with a minimum modal contact time of 90 minutes during the maximum day flow. An alternative means of disinfection, such as ultraviolet lamps (UV), could be applied provided such a system is designed to provide 5-log inactivation of viruses. In the case of the demonstration pilot, a small UV system has been added for disinfection of the filtered effluent from the demonstration pilot.

Reclaimed water could potentially be used for a demonstration project for urban landscape irrigation, such as the north perimeter buffer of the Wastewater Treatment Plant, the Forest Cemetery, River View Cemetery, or the Centennial Trail. Reclaimed water could also

potentially be used for dust control during the summer construction season or a variety of other non-potable water applications.

Near-Term Ammonia Reduction Improvements -- Integrated Fixed Film Activated Sludge (IFAS)

Near-term treatment process modifications are required to enhance the City's ability to remain in compliance with effluent discharge permit limits. One approach to enhancing the capacity to treat for ammonia that can be accomplished at moderate costs and relatively quickly compared to large scale plant improvements, is to add fixed film media to the existing biological treatment process.

Of the two IFAS alternative configurations available, fixed media and suspended media, only the fixed media technology represents a feasible approach for Coeur d'Alene in consideration of cost, constructability, and implementation schedule. As of October 2007, there were a limited number of vendors known to offer a fixed media IFAS technology product which can be installed at the Coeur d'Alene facility. It appears that the only viable supplier for consideration in Coeur d'Alene is Entex. Therefore, a sole source, pre-purchase of the Entex media was authorized by the City Council.

The IFAS retrofit for the Coeur d'Alene plant involved the installation of fixed film media modules in the existing Solids Contact Tank to increase ammonia removal capacity. Some mechanical, structural, and electrical modifications were required to make the installation possible. Since the IFAS modules were installed in existing process tankage, structural modifications were required to support the modules. Mechanical system modifications, chiefly aeration air supply for periodic agitation of the media, were required and adapted to the current aeration system at the plant. Limited electrical power system modifications were also needed to supply power to solenoid valves on the air system for periodic air purging.

The first retrofit was completed in June 2008 and was in operation for the summer season of 2008. An evaluation of treatment process effectiveness was conducted in the Fall of 2008 and additional IFAS modules were installed in the Solids Contact and Sludge Reaeration Tanks for the 2009 summer season. The total nitrification capacity is estimated to have increased from between 160 lbs/day and 200 lbs/day due to the 2008 and 2009 IFAS upgrades.

Staffing Requirements for an Advanced Water Reclamation Facility

Plant Staff Training

The Coeur d'Alene Wastewater Treatment Plant is preparing for a transition from conventional wastewater treatment plant to one of the most advanced treatment facilities in North America. This transition will undoubtedly present many challenges for the plant staff, including operators, maintenance personal, and laboratory staff. The new facility will not only feature new process design and operation strategies, but an entire array of new equipment with new maintenance

requirements, O&M manuals, new vendors, new troubleshooting procedures, and new calibration requirements.

Experiences at dozens of facilities across the country have shown that 5 years or longer is necessary for a new facility to operate at its fully optimized capacity. Given a compliance schedule of 9 years, and a schedule of approximately three years to construct the full-scale facility, the demonstration pilot offers the opportunity for the plant staff to familiarize themselves with many facets of the new facility.

Increased Analytical Skills

With new requirements to discharge less than 50 µg/l of effluent phosphorus, treatment processes are not only more advanced, but must be controlled within a narrow range of parameters. A slug load of high BOD / TSS from a process upset at the primary clarifiers may be manageable with a TF/SC process, but may have severe consequences for the BNR train. Treatment process control will take on an increased importance.

Timing of Phase 5C Improvements

The program schedule discussion is focused on compliance with a pending low phosphorus limit. However, the improvements planned for construction in Phase 5C could be needed much earlier than planned for phosphorus compliance to meet existing effluent ammonia limits as influent flow and loads continue to increase. IFAS improvements and other recent process operational changes have helped to achieve sufficient nitrification to comply with the current permit limits under current loading conditions. However, increased influent wastewater flow and loads can consume the recently added nitrification capacity and additional nitrification will be needed in approximately 3 to 5 years. Additional process control and chemical treatment may be required to mitigate the impact of increasing flows and loads on ammonia nitrogen removal until the Phase 5C improvements are constructed.

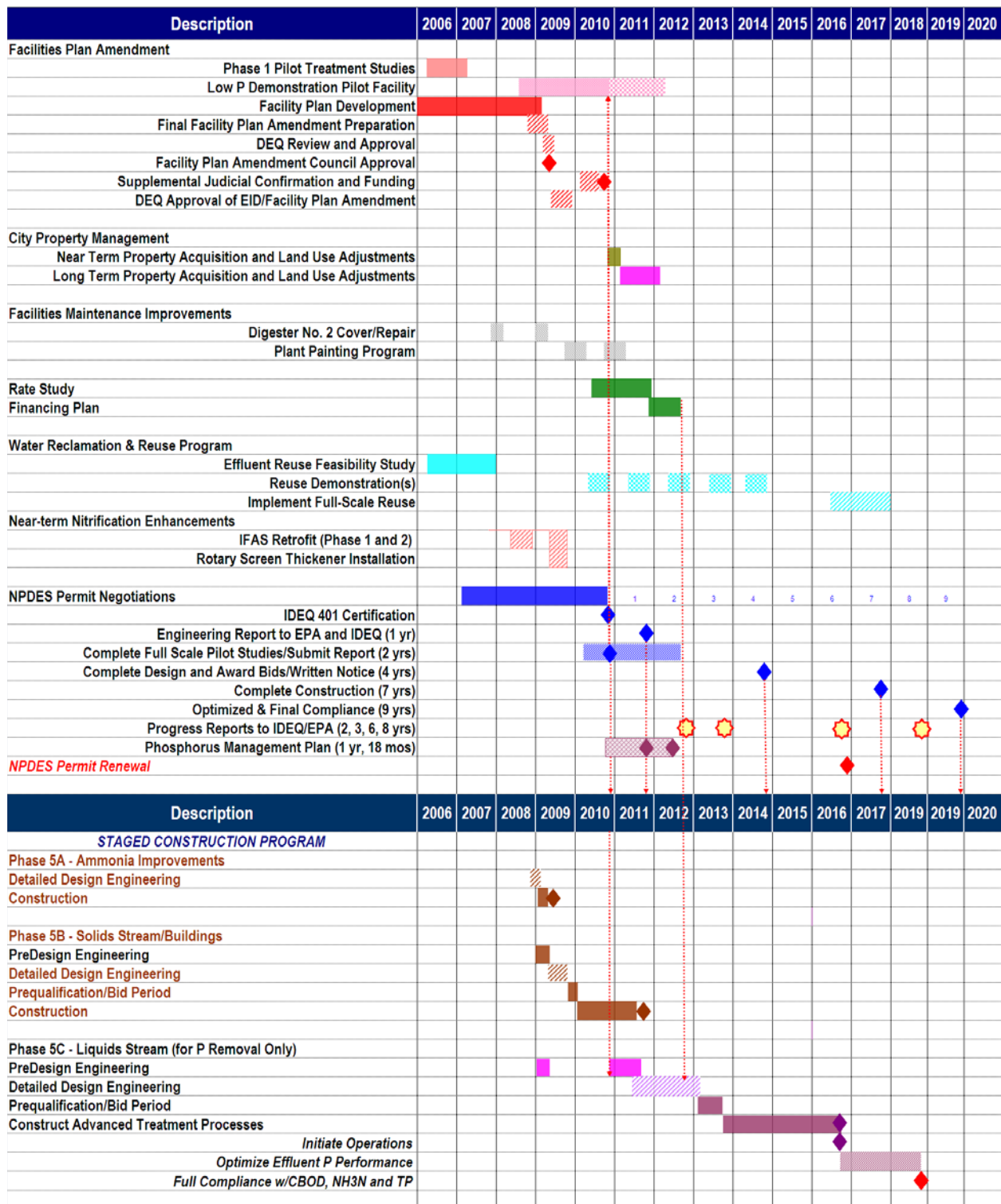


Figure 1. Program Schedule